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Backgrounder on Radiation Protection and the “Tooth Fairy” Issue

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Background

The U.S. Nuclear Regulatory Commission is the federal agency responsible for protecting public health and safety with regard to the use of nuclear materials in commercial nuclear power plants that generate electricity. Its regulations are based on sound science to make determinations that adequate protection of the public and the environment is maintained. As part of its responsibility, NRC requires plant operators to have effluent and environmental monitoring programs to ensure that the impacts from nuclear plant operations are minimized. The results of this monitoring have shown the presence of natural and weapons fallout radiation and in a few instances, very low levels of radioactive material of nuclear plant origin.

A number of studies by the Radiation Public Health Project[1] assert that levels of radioactive strontium-90 (Sr-90) are rising in the environment and that these increased levels are responsible for increases in cancers, particularly cancers in children, and infant mortality. The group claims that radioactive effluents from

nuclear power plants are directly responsible for the increases in Sr-90. In one study, researchers reported that Sr-90 concentrations in baby teeth are higher in areas around nuclear power plants than in other areas. This has sometimes been referred to as “The Tooth Fairy Project.” However, numerous peer-reviewed, scientific studies do not substantiate such claims.

Strontium-90 Sources

Strontium is a silvery-white alkaline earth metal that exists in several stable and unstable or radioactive isotopes (Sr-89 and Sr-90). Strontium-90 is a radioactive isotope that is produced in nuclear fission--splitting of an atom’s center that releases energy-- and has a half-life (decay of half its radioactivity) of about 28 years. In the United States, the primary pathway for Sr-90 to enter the body is through ingestion of contaminated foods and cow’s milk.

Strontium-90 does not occur naturally. It comes from three sources:

1) fallout from above-ground explosions of nuclear weapons testing worldwide from 1963 to 1980;
2) radioactive releases from the 1986 Chernobyl nuclear power plant accident in the Ukraine; and
3) radioactive releases from nuclear power plants into the environment.

By far, the largest source of Sr-90 in the environment (~99%) is from weapons testing fallout. Approximately 16.8 million curies of strontium-90 were produced and globally dispersed in atmospheric nuclear weapons testing until 1980 (UNSCEAR 2001)[2]. With a 28 year half-life, Sr-90 still remains in the environment at nominal levels. Numerous measurements were made during weapons testing which found that the worldwide average radiation dose from ingesting Sr-90 (1945 to present) is 9.7 millirem (about equal to radiation doses from a transpolar flight), and the dose from inhaling strontium-90 (1945 to 1985) is 0.92 millirem (about equal to the dose from an arm or leg x-ray). These doses are well below those doses known to cause any effects on health (NCRP 1991)[3]. The doses from Sr-90 in the environment are about 0.3% of the average annual dose a person in the United States receives from natural background radiation (~300 millirem).

As a result of the Chernobyl accident, approximately 216,000 curies of Sr-90 were released into the atmosphere. An increase in the incidence of childhood thyroid cancer in the area directly affected by the accident has been attributable to radioiodine ingestion. No other increase in overall cancer incidence or mortality has been observed that can be attributed to radiation from the accident (UNSCEAR 2000)[4].

The total annual release of strontium-90 into the atmosphere from all 103 commercial nuclear power plants operating in the United States is typically 1/1000th of a curie. (NUREG/CR-2907, Vol. 12)[5]. At an individual nuclear power plant, the amount of Sr-90 is so low that it is usually at or below the minimum detectable activity of sensitive detection equipment. Radiation doses from Sr-90 to individuals living within 30 miles of a nuclear power plant would be a tiny fraction of less than one millirem. As indicated above, nuclear power plant emissions of Sr-90 are inconsequential compared with other man-made sources and, thus, it is reasonable to conclude that the vast majority of Sr-90 that can be detected in, for example, baby teeth would be attributable to fallout from nuclear weapons testing or, possibly, the Chernobyl accident.

Ability for Strontium-90 to Cause Cancer

Sr-90, if ingested, tends to mimic calcium when it is in the body and therefore becomes concentrated in calcified tissues such as bones and teeth. If ingested in quantities that produce very large radiological dose rates (about a thousand times higher than doses we all receive from natural radiation), Sr-90 is known to increase the risk of bone cancer and leukemia in animals, and is presumed to do so in people. Below these

doses, there is no evidence of excess cancer [Raabe 1994][6].

Radiation Monitoring at Nuclear Power Plants

Limits on Plant Discharges (Effluents)

The NRC has established strict limits on the amount of radioactive emissions allowed to be released from nuclear plants to the environment and the resulting exposure for members of the public and the plant workers. (NRC requirements are in Title 10 of the Code of Federal Regulations, Part 20, Appendix B, http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-appb.html). The concentration of radionuclides that may be released is limited to levels which, if inhaled or ingested continuously over the course of a year, would produce a dose of no more than 100 millirem. These limits are based on radiation protection recommendations of both the National Council on Radiation Protection Measurements and the International Commission on Radiological Protection organizations resulting from ongoing research. Nuclear power plants are further limited by their license conditions to keep radioactive material in effluents "as low as reasonably achievable" so that dose criteria for releases to unrestricted areas are five millirem for releases into the air and three millirem for liquid releases.

All power plant operators are required to monitor radioactive airborne and liquid discharges from the plant and to file a report of these discharges annually with the NRC. These reports, which are publicly available, list the radioactive isotopes released, the quantity released and the radiation dose to the public. The concentrations of radionuclides released into the environment from a nuclear facility are generally too low to be measurable outside the plant's boundary. For this reason, any Sr-90 detected in areas near a nuclear power plant would not likely have come from the plant, but would be attributed to fallout from nuclear weapons testing or from the Chernobyl accident.

Plant Environmental Monitoring

In addition to limits on effluent releases, plant operators maintain an environmental monitoring program that is reviewed and inspected regularly by NRC to ensure compliance with its requirements. To demonstrate that the plant is within the regulatory limits, operators regularly sample and analyze the surrounding soil, vegetation, cow's milk, and water. In a given year, a plant operator samples and analyzes hundreds of environmental samples. The results of environmental monitoring and assessment efforts are provided to the NRC in an annual report, which is available to the public.

It is reasonable to conclude that Sr-90 would be seen in the environment well before it is seen in baby teeth. In order for it to be in the environment from nuclear power plants, it would have to be seen in significant quantities in the effluent stream from these facilities. However, Sr-90 is not present in the effluents at such levels.

Studies Examining Health Effects Around Nuclear Power Plants

In 1990, at the request of Congress, the **National Cancer Institute**[7] conducted a study of cancer mortality rates around 52 nuclear power plants and 10 other nuclear facilities. The study covered the period from 1950 to 1984, and evaluated the change in mortality rates before and during facility operations. The study concluded there was no evidence that nuclear facilities may be linked causally with excess deaths from leukemia or from other cancers in populations living nearby.

In June 2000, investigators from the **University of Pittsburgh**[8] found no link between radiation released

during the 1979 accident at Three Mile Island power plant and cancer deaths among nearby residents. Their study followed 32,000 people who lived within five miles of the plant at the time of the accident.

The **Connecticut Academy of Sciences and Engineering**[9], in January 2001, issued a report on a study around the Haddam Neck nuclear power plant in Connecticut and concluded radiation emissions were so low as to be negligible.

The **American Cancer Society**[10] in 2001 concluded that although reports about cancer clusters in some communities have raised public concern, studies show that clusters do not occur more often near nuclear plants than they do by chance elsewhere in the population. Likewise, there is no evidence that links Sr-90 with increases in breast cancer, prostate cancer, or childhood cancer rates. Radiation emissions from nuclear power plants are closely controlled and involve negligible levels of exposure for nearby communities.

Also in 2001, the **Florida Bureau of Environmental Epidemiology**[11] reviewed claims that there are striking increases in cancer rates in southeastern Florida counties caused by increased radiation exposures from nuclear power plants. However, using the same data to reconstruct the calculations on which the claims were based, Florida officials were not able to identify unusually high rates of cancers in these counties compared with the rest of the state of Florida and the nation.

In 2000, the **Illinois Public Health Department**[12] compared childhood cancer statistics for counties with nuclear power plants to similar counties without nuclear plants and found no statistically significant difference.

Measuring Radioactive Substances in People

Interpreting measurements of radioactive material in people is difficult unless one knows what each individual was exposed to, when the exposures occurred, and by what routes they occurred (ingestion, inhalation, etc.). In particular for Sr-90, dietary contributions from foodstuffs produced out of the region must be considered. Also, fallout in soil across the U.S. is not uniform. Rainfall, wind direction and soil composition all affect the levels of Sr-90 in soil. Finally, migration must be accounted for, because people may have lived and acquired radionuclides from a number of geographic locations that are not near a nuclear power plant. In addition, radioactive substances may come from a variety of sources. In the case of Sr-90, the primary source has always been fallout from atmospheric weapons tests (UNSCEAR 2001).

Cause-and-Effect Relationships and Scientific Methodology

Authors of the Radiation Public Health Project reports have stated or implied that claimed statistical associations between cancer rates and reactor operations are cause-and-effect relationships. However, statistical association alone does not prove causation, and well-established scientific methods must be used to determine that for two things that appear to be associated over time, it can be concluded that one causes the other.

A simple example helps illustrate this point. A college professor gives the following example of a causal inference: “In the winter I wear boots. In the winter I get colds. Therefore, boots cause colds.” A strong statistical association exists between wearing boots and the health effect of colds. There is, however, an argument about whether boots **cause** colds.

There are principles of good science that are recognized by the scientific community such as whether a study can be replicated; whether it has considered all data or was it selective (e.g., in the population or in the years

studied); whether a study evaluated all possible explanations for the observations; was the data used evaluated for validity and reliability; and whether the study's conclusions were subjected to independent peer review, evaluation and confirmation.

There are a number of questions about the Health Project studies with regard to methodology, assumptions, and conclusions. Generally, these studies have not followed good scientific principles. Frequently, they have

- not established control populations for study;
- not examined the impacts of other risk factors;
- used very small sample sizes to draw general conclusions;
- not performed environmental sampling and analysis;
- selectively chosen to ignore data in certain geographic locations or during certain periods of time because they did not "fit";
- not subjected their data to the independent peer review of the scientific community as a whole; and
- used an incorrect half-life for Sr-90 which gives a false impression that strontium levels in the environment are decaying more rapidly than in baby teeth.

The evaluation of health effects from exposure to radiation is an ongoing activity of the NRC's involving public, private and international institutions. The NRC routinely seeks out new scientific information that might reveal health and safety concerns. It reviews independent studies of nuclear safety issues and embraces opportunities to inform the public about the results of such reviews. Based on all the preceding discussion, NRC finds there is little or no credibility in the studies published by the Radiation Public Health Project.

Key Points

The Radiation Public Health Project (RPHP) has conducted a number of studies claiming radioactive strontium-90 (Sr-90) in the environment is responsible for increases in cancers.

One of the RPHP's studies, sometimes referred to as the "Tooth Fairy Project," reported that Sr-90 concentrations in baby teeth are higher in areas around nuclear power plants than in other areas.

Numerous peer-reviewed scientific studies do not support the RPHP's claims. NRC finds there is little or no credibility in the RHP's studies.

Approximately 99% of Sr-90 in the environment came from atmospheric testing of nuclear weapons. The second largest source of Sr-90 in the environment was the Chernobyl accident.

The amount of Sr-90 from all commercial nuclear power plants is a tiny fraction of the amount from Chernobyl.

The estimated radiation dose from all sources of Sr-90 in the environment is approximately 0.3% of the dose that the average person in the United States receives from natural background radiation. These dose levels are well below the levels that are known to cause any health effects.

The NRC requires nuclear power plant licensees to monitor the releases of radioactivity from their facilities to the environment and to annually report these releases to the NRC. Additionally, these licensees are required to monitor the environment around their facilities and report results annually to NRC. The NRC routinely inspects these aspects of nuclear power plant licensee performance.

Footnotes

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